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Ankaran, 8.–10. oktober 2014

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ABSTRACTS AND FIELD TRIPS

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PHYSICAL-MECHANICAL AND MINERALOGICAL-PETROGRAPHICAL CHARACTERISTICS OF THE DIABASES AT THE LOCALITY "UDOVO" (VARDAR ZONE, REPUBLIC MACEDONIA)

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A b s t r a c t: The diabases from the Udovo locality (Vardar area, Republic of Macedonia) have been analyzed in order to determine the possibility of their utilization as construction stone. The analyses and the laboratory tests have been performed on samples of diabases and quartz keratophyre. The samples were taken from the surface layers.
The results from their physical and mechanical analyses showed that these rocks meet the requirements for their utilization as construction stone suitable for all fractions of asphalt – concrete, concrete aggregate, material for compaction of roads, stone dust and other application in the civil engineering related to the traffic infrastructure. Additionally, the quality of the stone is higher in the deeper parts of the terrain, where the external influences have little effect.
Key words: diabase; Udovo; construction stone; mineralogical petrographic structure; structural-texture characteristics; chemical characteristics; physical-mechanical characteristics

INTODUCTION

The Udovo area is located in eastern Macedonia, 12 km northwest of Valandovo and 15 km south-east of Demir Kapija. Nearest populated place is the village Udovo, from which the space provided for geological research is about 3 km away in the north-west direction. The adjacent area of the studied locality in the past has been explored by many researchers for different purposes and uses. To preserve the primacy of geological research in chronological order, data of individual researchers, which have worked directly on the aforementioned terrain will be presented.
Cvijić (1906) was the first researcher who found and gave the main features of the Vardar depression or central Balkan potolina as he called it. Especially important is the work of Kosmat (1924) in which he gives a complete overview of geology of the Macedonia. He first made it different Vardar zone as a separate tectonic unit between the Serbian–Macedonian mass and Pelagonia massif.
Tajder (1939) provides data on physiography, chemical composition and genesis of gabbroide massive Dren–Boul. Tuchan (1940) has made several routes and concluded that on the studied area are present granite, gabbro, diabase, melaphyres and other types of rocks. Izmajlov (1948) conducting surveys in the vicinity of the Iberli village provided information on the geology of the nearby environment. Meyer (1960) gave details for mineralogical - petrographic characteristics of some rocks from the Udovo vicinity. Stračkov (1963, 1966) provided detailed data on the geological evolution of the southern part of the Vardar zone and tectonical composition of the Gradeška mountain and its immediate surroundings.
In the period 1962 – 1974, the immediate vicinity of the research area was studied in details by

numerous researchers in the preparation of the OGK of SFRY in scale 1 : 100 000 sheets of Kavadarci, Kožuf and Gevgelija. From metallogenetic aspect Vardar zone is the best studied by Ivanov (1966). Within the plate-tectonic interpretation in the last few decades new views about the nature and significance of the Vardar zone have been indicated by Karamata (1974), Dimitrijević (1974), Aleksić et al. (1974), Arsovski et al. (1984). Ivanov, Dumurdžanov and others (1987) provide the latest detailed information on petrological and chemical characteristics of gabbro-basaltic massive Demir Kapija–Gevgelija. Dumurdžanov and Petrov (1992) gave many details for lithostratigraphic and chemical characteristics of the Vardar oceanic crust in the territory of the Republic of Macedonia. Latest data on the mineralogical-petrographic, chemical and geochemical characteristics of gabbros and diabases from the immediate surroundings of the studied area can be found in the works of Spasovski (2001, 2005).

RESEARCH METHODS USED

The mineralogic-petrographic research have been performed at the Faculty of Natural and Technical Sciences in Štip by the author of this paper, while the chemical composition of the diabase is determined in the chemical laboratory of Železarnica in Skopje. The research of the physical-chemical characteristics was performed in the laboratory at the Faculty of Civil Engineering in Skopje. The examinations were performed during 2010. Because the rock masses are not well disposed, the samples were taken from the surface of the terrain. As a consequence in the samples themselves there are some cracks which is a result from the great influence of the atmosphere. However, the study of the samples have shown credible values of their physical - mechanical characteristics. It is certain that the samples from the greater depths would give much better results.

GEOLOGICAL CHARACTERISTICS

The geological structure of the Udovo locality includes the following types of rocks: amphibolites chists and marbles, diabases and quartz, keratophyres and alluvial sediments (Fig. 1).

The amphibolite schists are fine to medium stratified, frequently intercalated by marbles. The striped varieties are consisted of alternate thin stripes of aplitic structure and stripes with prevailing colored ingredients. The stripes thickness can reach up to 1 cm. Rarely, there are homogenous layers without striped structure. They are constituted of amphibole, quartz and feldspar. The most frequent from the amphiboles is the hornblende and some samples have acicular amphibole-actinolite, but in very small quantities. The most frequent feldspars are the plagioclases, which are mostly kaolinated and sericitized, but sometimes they can be prenitized. The secondary ingredients are the epidote, sphene, leucoxene and ore minerals.

Comparing to the colorless, the structure of the colored components is wide ranged. Their structure is granoblastic with a tendency to nematoblastic, and rarely porphyroblastic. According to some indications, these rocks may have magmatic and sediment origin. The marbles are presented in layers – stripes with unequal length and thickness. They have grey, dark-grey and at places blue color. Depending on the texture characteristics, they are massive. Also, they can be parceled in smaller or bigger blocks by a system of explosions.

Fig. 1. Geological map of the locality Udovo (Spasovki et al, 2010)
1. alluvial sediments, 2. diabase, 3. amphibolite schists, 4. marbles.

The diabases are characterized with green and grey-green color, homogenous and massive textures (Fig. 2). They are small-grained and the size of the grains do not exceeds 1 cm. They are quite solid and stern. Frequently, they are crossed with calcite and epidotic veinlets. At some places, the diabases have mostly parallelopiped, and sometimes sphere excretion. The diabases having parallelopiped excretion are compact and solid. There also have multidirectional fissures.
The following modal structure is provided for the diabases by integrating: plagioclases 45–74%, pyroxenes 35–45% and magnetite 5–15%. Among the diabases there is a certain number of samples with a presence of phenolcrystals, thus they can be named as porphyry diabases. The phenocrystals are grains of pyroxenes and plagioclases, which are usually 3–4 cm large and rare, and the basis is subophitic and ophitic, as at the normal diabases. It is very rarely noticed at the diabases and quartz, thus they turn in quartzdiabases.
Quartz-keratophyres are quite hard rocks with massive and compact texture and small-grained structure. They have pink-brown color over the entire surface; at the breaking surfaces, they have darker Fe-oxides coatings, as well as dark-grey manganization coatings. The cross section shows white phenocrystals – rare with size of 1–2 mm.

Fig. 2. Dark green diabase

The contemporary alluvial layers are tightly connected with the riverbed of the Airan River. They are represented mostly with gravel and sand whose structure is tightly linked with the structure of the rocks developed in the upper flows of the above-mentioned river. Taking this into consideration, down stream of Airan river, there are mostly gabbro diabases. These layers are mutually mixed, but they are characterized with the feature to have rough material at the upper flow, and more processed and gravel material in the lower flow.

PETROGRAPHIC-MINERALOGICAL CHARACTERISTICS

There were some representative samples from the locality Udovo selected for the mineralogicpetrographic studies. Sixthin sections were made which were examined with a transmitted light polarized microscope made by Leitz, Wetzlar, Germany. The mineralogic-petrographic studies were performed at the Faculty of Natural and Technical Sciences at the Institute of Geology by the author of this paper.

The examined diabase samples are characterized with small-grained structure, solid, massive and compact texture. They have dark grey-green color, and at their surface at places, thin coathings of brown color from Fe-oxides may be noticed. The rock has holocrystalporphyrin, ophiticsubophitic structure represented with stick-like crystals on the plagioclase with length of 1 mm (Figs. 3, 4). Between them, the basis – matrix is constituted of holocrystal structure from amphibole, pyroxene and plagioclase, which are well joint between in the subophitic structure (Fig. 5, 6). The main minerals in the rock are plagioclase, amphibole, pyroxene, extremely rare grains of olivine, and the secondary are epidote, calcite and ore minerals. The plagioclase in the basis appears as stick-like short rectangular crystals, and the space between is filled by amphibole and pyroxene in short table-like forms as well as in the secondary minerals (Figs. 7, 8).

The plagioclase is little metamorphosed, and its products are calcite, slightly clayed, amorphed and very slightly sericitized. According to its characteristics, it is probably the type of intermediary to slightly basic plagioclase.

The amphiboles are represented with actinolite-uralite and rare crystals of hornblende. They appear as short-panel forms. At places there are hexagonal elongated crosses, which in the middle are relict remains of pyroxene, and on the periphery there are transmutes – metamorphosed in amphibole – uralite and calcite. The pyroxene appears as mixed with amphibole, i.e. partly metamorphosed in uralite – actinolite. Frequently, there are forms that are completely metamorphosed in calcite and epidote, and probably they are some colored mineral. The calcification is occurring very frequently. Rarely, there are grains of olivine in irregular form, with size of about 0.5 mm and they are usually several into one group.

The epidote as a secondary mineral appears in larger irregular grains, as well as in little veins – small-grained. The chloritization is occurring sometimes in thin flakes. The whole rock is evenly spattered with mine mineral of magnetite – ilmenite (oxides).

The quartz keratophyre is quite hard rock with massive and compact texture and smallgrained structure. It has pink-brown color all over its surface, on the refracted surfaces there are some darker Fe oxide coatings, as well as dark grey lathers of manganization. The fresh cross section shows white phenocrystals – rare, with 1–2 mm size. The rock has holocrystal porphyrin structure. The phenocrystals appear as hefty rectangular crystals of plagioclase (about 1 mm long) and rare elongated forms of colored mineral metamorphosed in epidote and chlorite (Figs. 9 and 10). The matrix is microcrystal built of feldsparplagioclase in irregularly crystallized grains, and often, radial grainy crystal forms of feldspar can be noticed. The plagioclase is slightly altered and clayed. It is probably intermediate to slightly acid plagioclase. The basis is usually made of quartz in irregular grains, somewhat larger than the feldspar. Separate quartz crystals appear as partly crystallized phenocrystals, and more frequently are with an irregular form. In addition, there are chlorite, epidote and mine mineral – leucoxene.

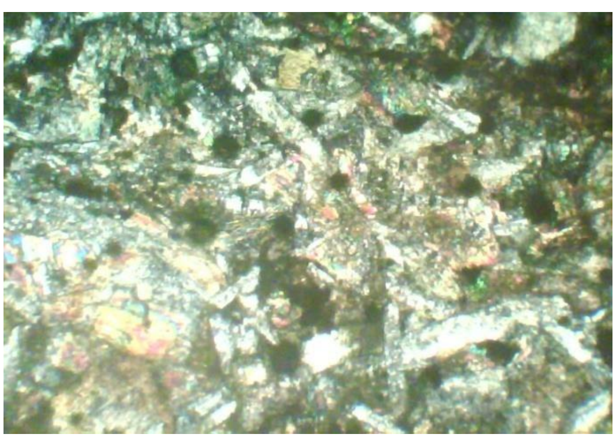

Fig. 3. Diabase with clearly expressed barred crystals of plagioclase (N+)

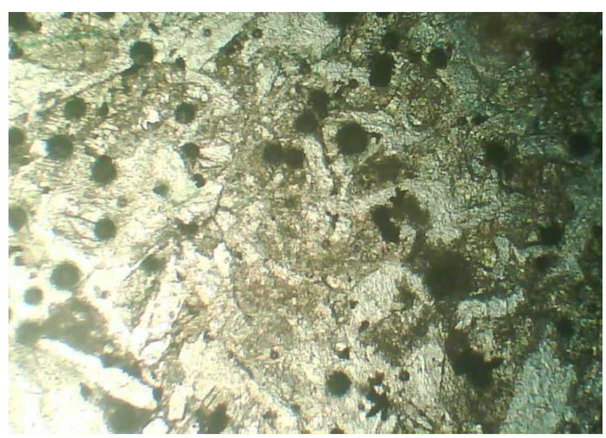

Fig. 4. Diabase with clearly expressed barred crystals of plagioclase (N-)

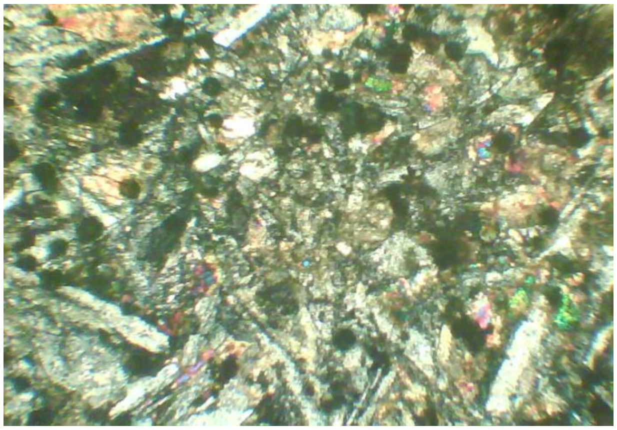

Fig. 5. Uniting the amphibole, pyroxene and plagioclase in subophitic structure (N+)

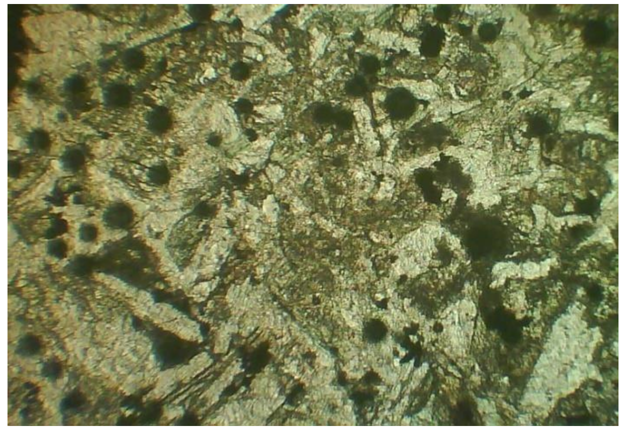

Fig. 6. Uniting the amphibole, pyroxene and plagioclase in subophitic structure (N-)

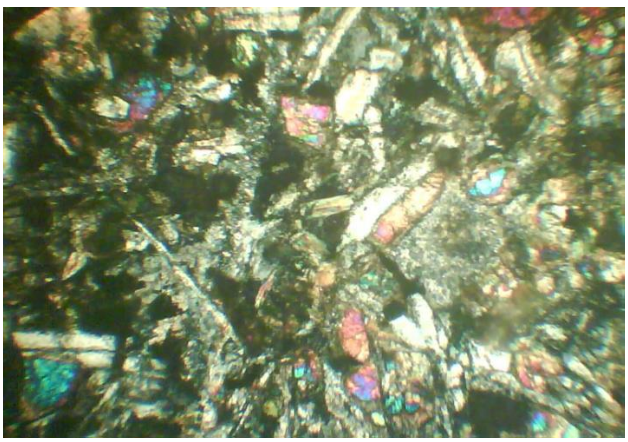

Fig. 7. Ophitic-subophitic structure of diabase consisted of barred and rectangular plagioclase whose gap is filled with pyroxene – augite (N+)

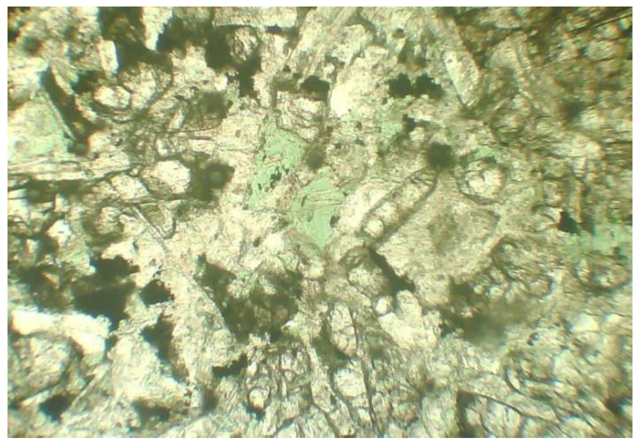

Fig. 8. Ophitic-subophitic structure of diabase consisted of barred and rectangular plagioclase whose gap is filled with pyroxene – augite (N-)

Fig. 9. Large rectangular crystals of plagioclase and elongated grains of mine mineral (N+)

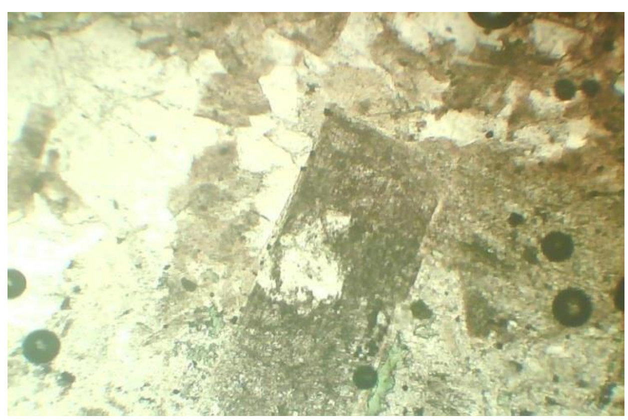

Fig. 10. Large rectangular crystals of plagioclase and elongated grains of mine mineral (N-)

The chlorite can be obtained in irregular coatings and bundles, and on the periphery of the oatings there are micro grains of ore minerals. The chlorite is a secondary mineral. The participation of the colored minerals is very small, approximately 20%. The leucoxene and the magnetite appear as ore minerals. The leucoxene is quite frequent and appear in irregular forms. The magnetite is also quite frequent and appears as idiomorphic cubes. Taking into consideration the microscopic aspects, the quantitative participation of feldspar – plagioclase and quartz (the quartz takes little participation) in the rock is about 80%, which provides it great firmness.

PHYSICAL-MECHANICAL CHARACTERISTICS

In order to determine the basic physical and mechanical characteristics of the rock masses, examinations pursuant the valid standards and recommendations ISRM (International Society for Rock Mechanics) have been performed: Determination of the index of strength (Is) at rockmasses; Determination of the uniaxial strength of pressure; The examinations of the strength characterristics of the monolithic diabase parts from the Udovo locality have been performed at the Civil Engineering Faculty in Skopje, Department of Geotechnics. The samples have been put to a test of strength to pressure, point load, volume, weight, water absorption, consistence to ice influence and grinding upon the "Los Angeles" as basic classifycation parameters.

Fourteen samples have been examined with the test of point load and three samples for strength of pressure in dry, saturated condition and after 25 cycles of freezing and defrosting. In addition, three tests upon the Los Angeles method have been performed, and the moist absorption during saturation has been measured for 6 test bodies.

The results from the strength index present that the value of the Index of strength is within the following limits:

Value of Is (50) = 8.46 – 12.48 MPa depending on the examined sample.

Results from the strength of pressure in dry and moist condition are presented in Table 1. The results from the examinations of the strength after 25 cycles of freezing and defrosting are presented in Table 2.

The coefficient of softening and resistance to the influence of ice are presented respectively:

$$Kom = \sigma pv/\sigma p = 172.43/197.2 = 0.874$$

$$Kom = \sigma pm/\sigma p = 170.5/197.2 = 0.86$$

Table 1. *Results form the examination of strength of pressure in dry and moist condition*

Sample mark	Dimensions a/b/h (mm)	Strength of pressure σpMPa	Absorption of moisture U (%)
U_2 (dry)	5.05/5.0/5.28	179.6	0.25
U_3 (dry)	5.07/5.25/5.30	175.6	0.27
U_5 (dry) 0.054	5.10/5.25/5.30	236.50	0.054
Average		197.23	0.191
U_1 (wet)	5.02/5.05/5.10	172.2	0.15
U_4 (wet)	5.07/5.10/5.05	169.50	0.22
U_5 (wet)	5.10/5.05/5.10	175.60	0.089
Average		172.43	0.153

Table 2. *Results from the examinations of the strength after 25 cycles of freezing and defrosting*

Sample mark	Dimensions a/b/h (mm)	Strength of pressure σpMPa
U_2 (dry)	5.06/5.0/5.20	173.8
U_3 (dry)	5.06/5.15/5.20	172.50
U_5 (dry) 0.054	5.20/5.20/5.05	165.2
Average		170.5

The volume weight of the diabase, depending on the sample, ranges from γ = 26.95 – 29.14 kN/m^3 (average = 27.974 kN/m^3).
The value of Los Angeles, for the three series of samples is presented in Table 3.
All results show that the material is appropriate for utilization of all asphalt fractions – concrete, concrete aggregate, tampon material, stone dust and other usage in the construction engineering related to the traffic infrastructure.

Table 3. *Results from examinations regarding attrition upon the Los Angeles method*

Sample mark	M1 – mass of the dry rock before attrition (g)	M1 – mass of the dry rock before attrition (g)	La (%)
1 D-2 3–12 m	5000	3960	20.80
2 D-2 21.2–30.0 m	5000	4120	17.60
3 D-3 1–12 m	5000	4050	19.0
Average			19.13

CONCLUSION

The samples were taken from the surface parts of the terrain where the outdoor influences have been quite intense. In the deeper layers of the ground, the rock mass is found as blocks and less affected by the atmospheric influence which enables a better quality. Based on the results received from the analyses it can be concluded that it can be used as construction stone.
The examined rocks are characterized with dark green color, massive structure and small presence of cracks.
The diabases with their dark green color are mostly prevalent on the examined area and they clearly differ from the other types of rocks.
From the mineralogical point of view, they are silicate rocks structured mostly of plagioclase, pyroxene and rarely amphibole. The samples are determined as small-grained diabase with ophitic to subophitic structure. According to the performed chemical examinations, the diabases

have permanent chemical structure with contents of SiO_2 from 50 to 54%.

According to the petrologic, mineralogicalmicroscopic examinations, physical-mechanical parameters and chemical analyses, the examined diabases may be widely applied in the civil engineering, mostly in traffic civil engineering as construction stone, suitable for utilization at all fractions of asphalt – concrete, concrete aggregate, material for compaction of roads, stone dust and other applications in the construction related to the traffic infrastructure.

In addition, it can be used as an architectural stone, depending on the microtectonics, in order of provision of larger blocks.

Pursuant the performed examinations for determination of the physical-mechanical parameters, it is considered that the strength of the diabase is sufficiently high.

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